PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2002-272674
(43)Date of publication of application : 24.09.2002

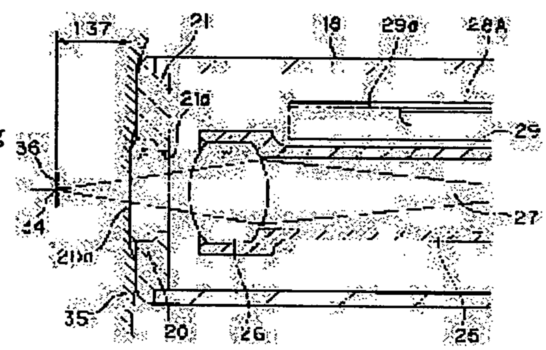
(51)Int.CI. A61B 1/00
G01N 21/17
G02B 23/26
G12B 21/02

(21)Application number : 2001-072636
(22)Date of filing : 14.03.2001

(71)Applicant : OLYMPUS OPTICAL CO LTD
(72)Inventor : KAMETANI TAKAYUKI
SUGA TAKESHI

(54) OPTICAL SCANNING PROBE DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an optical scanning probe device suited for obtaining the image information of a desired part to be inspected, while reducing the influence of light reflected by a light transmitting member.
SOLUTION: At the leading end of a probe, a condensing lens 26 held against the leading end of a retaining member 25 inside an optical frame 18 causes illuminating light emitted from the leading end of an optical fiber to be transmitted through a light-transmitting leading end cover 20 positioned in front of it, the light is focused in the form of a spot at the position of a focus 34 inside and near the surface of a living tissue 35, against which the front surface 20a of the leading end cover 20 is pressed. When the light reflected from the living tissue 35 near the focus 34 is received via a reverse optical path, the distance L37 between the front surface 20a and the focus 34 is held within a predetermined range whereby the amount of the reflected light received by the cover 20 is made greater than the amount of the light received from near the focus 34 on the living tissue 35 to provide image information with good S/N.



LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] In the light-scanning probe equipment which transmits the reflected light of said illumination light from said tested part which scans the focus of the illumination light which light equipment emits to a tested part, and is obtained by this scan to observation equipment Among two or more light transmission nature members arranged on the optical path of said illumination light, the distance of a tested part, the nearest light transmission nature member, and the focus of said illumination light Light-scanning probe equipment characterized by having arranged so that the amount S of reflected lights which reflects by the total amount N and tested part of the reflected light which reflect by the end face of said light transmission nature member, and are transmitted to observation equipment, and is transmitted to observation equipment may serve as S>N.
[Claim 2] In the light-scanning probe equipment which transmits the reflected light of said illumination light from said tested part which scans the focus of the illumination light which light equipment emits to a tested part, and is obtained by this scan to observation equipment The member arranged around a tested part and the nearest light transmission nature member among two or more light transmission nature members arranged on the optical path of said illumination light Light-scanning probe equipment with which a projection and said focus are characterized by being located in the crevice which the same field as said lobe tip or said lobe forms to the direction of said tested part.
[Claim 3] Light-scanning probe equipment according to claim 2 characterized by having arranged so that the amount S of reflected lights which reflects the distance of the specimen, the nearest light transmission nature member, and a focus by the total amount N and tested part of the reflected light which reflect by the end face of a **** fitness member, and are transmitted to observation equipment among two or more light transmission nature members arranged on an optical path, and is transmitted to observation equipment may serve as S>N.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is transmitted with the optical fiber which prepared the illumination light from light equipment in the probe, scans the illumination light by which outgoing radiation is carried out from an apical surface, and relates to the light-scanning probe equipment which receives the reflected light from a tested part side, and obtains optical image information.
[0002]
[Description of the Prior Art] The confocal microscope of the miniaturized probe mold is inserted into a coelome in recent years, and direct observation / technique to diagnose is being established, without extracting a body tissue. A confocal microscope irradiates the illumination light at a photographic subject, images the reflected light as input, and is effective in removing the reflected light from the photographic subject shifted from a focal location. This is called Z resolution (resolution of the depth direction). The light-receiving quantity of light changed according to the depth location of a photographic subject, and the full width at half maximum is defined as Z resolution (refer to drawing 17). In addition, about light source wavelength, when lambda and a photographic subject refractive index are set to n and optical-system numerical aperture is set to NA, the Z above-mentioned resolution becomes 1.28lambdan/(NA-NA).
[0003] On the other hand, the amount of reflected lights by which incidence is carried out to a microscope from a photographic subject decreases as the observation section becomes deep from a front face very as small [a reflection factor] as 1 / 1000 - 1/100000 as for a body tissue. Usually, it becomes important positioning [of the depth direction of removal of the lightwave signal from the cover glass as a light transmission nature member especially prepared for the purpose of protection of optical system near a focus except the body tissue by which incidence is carried out to a microscope in order to catch a body tissue as an image for the above reason, although the depth of the range of a body tissue front face to dozens of micrometers is observed in the hundreds of micrometers visual field range in the confocal microscope of a probe mold, and a focus].
[0004] It inserts into a coelome and the conventional technique about the distance (working distance: describe it as WD henceforth) of the focus of the illumination light related to claims 1 and 3 and cover glass cannot be seen in the present condition in the confocal microscope of the probe mold which observes a body tissue on cell level.
[0005] Moreover, as a conventional technique about positioning of the depth direction related to claims 2 and 3, the approach of attracting and fixing in the cup which prepared the observation organization near the focal lens system, and the method of suppressing an observation part with tip covering transparent like JP,2000-126114,A are mentioned as opened to JP,3-87804,A.
[0006]
[Problem(s) to be Solved by the Invention] Since there was no conventional technique related to claims 1 and 3, there was a case where the signal from cover glass became large from the reflected light (signal) from the specimen, and the image of the specimen for which it asks was not obtained.
[0007] Moreover, the trouble of the conventional technique concerning claims 2 and 3 is as

follows. Since it fixes in a cup by attracting an observation part in case of the configuration of JP,3-87804,A, since suction opening is required, actuation serves as a failure of a miniaturization troublesome.
[0008] Moreover, to the direction of a field, although firmly fixed to the pushing direction in case of the configuration of JP,2000-126114,A, since the fixed force is weak, when the visual field range is comparatively as narrow as hundreds of micrometers, the probe only moved several small mm, an observation part separates from the visual field range, and suitable observation cannot be performed.
[0009] (The purpose of invention) This invention was made in view of the point mentioned above, and aims at offering the light-scanning probe equipment suitable for obtaining the image information of a tested part which makes small effect of the reflected light by the light transmission nature member (cover glass), and asks for it.
[0010] Also let it be the purpose to offer the light-scanning probe equipment suitable for setting up the focus of the illumination light near the front face of a tested part simply, and obtaining the optical image information to a tested part.
[0011]
[Means for Solving the Problem] In the light-scanning probe equipment which transmits the reflected light of said illumination light from said tested part which scans the focus of the illumination light which light equipment emits to a tested part, and is obtained by this scan to observation equipment The total amount N of the reflected light which reflects the distance of a tested part, the nearest light transmission nature member, and the focus of said illumination light by the end face of said light transmission nature member among two or more light transmission nature members arranged on the optical path of said illumination light, and is transmitted to observation equipment The effect of the reflected light by the light transmission nature member is controlled, and it enables it to obtain the image information to the specimen by having arranged so that the amount S of reflected lights which reflects by the tested part and is transmitted to observation equipment may serve as S>N.
[0012] In the light-scanning probe equipment which transmits the reflected light of said illumination light from said tested part which scans the focus of the illumination light which light equipment emits to a tested part, and is obtained by this scan to observation equipment The member arranged around a tested part and the nearest light transmission nature member among two or more light transmission nature members arranged on the optical path of said illumination light It sets up so that a projection and said focus may be located to the direction of said tested part in the crevice which the same field as said lobe tip or said lobe forms, and it enables it to obtain the optical image information to near the front face of a tested part easily.
[0013]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing.
Drawing 1 thru/or drawing 19 start the gestalt of operation of the 1st of this invention. (Gestalt of the 1st operation) Drawing 1 shows the optical whole diagnostic-equipment configuration equipped with the gestalt of the 1st operation, and drawing 2 shows the configuration of the optical transceiver section. Drawing 3 shows the configuration of a control section and drawing 4 shows the configuration by the side of the tip of a probe. Drawing 5 shows the configuration of an actuator and drawing 6 shows the part which fixes an actuator to a holddown member by A view of drawing 4 (B). Drawing 7 shows the part which fixes an actuator to pars intermedia material by B view of drawing 4 (B). Drawing 8 shows the part which fixes an actuator to an attachment component by C view of drawing 4 (A). Signs that drawing 9 presses the apical surface of a probe against a body tissue, and an optical diagnosis is carried out are shown. Drawing 10 shows the configuration by the side of the tip of the probe of a modification, and drawing 11 shows the part in which the vacuum evaporationo film of the light reflex nature by the side of the rear face of a condenser lens is prepared. Drawing 12 shows the cross-section structure of a scanning mirror, and drawing 13 shows the mirror section before forming an electrode etc. Drawing 14 shows the mirror section in which the electrode etc. was formed, and the optical path which condenses with a focus from the optical fiber tip at the time of drawing 15

and drawing 16 setting up the wavelength of the light source concretely, and setting the working distance to 1.0mm and 2.0mm is shown, respectively. Drawing 17 shows the property of a focus and the light-receiving reinforcement of the light to the distance before and behind that, signs that drawing 18 drives an actuator with the probe of drawing 4 , and the field scan of the light is carried out are shown, and drawing 19 shows signs that drive a scanning mirror and the field scan of the light is carried out with the probe of drawing 10 .
[0014] The optical transceiver section 2 which receives the light which the optical diagnostic equipment 1 transmitted the light for an optical diagnosis, or was used for the optical diagnosis as shown in drawing 1 , By connecting with this optical transceiver section 2, controlling actuation of the optical transceiver section 2, or connecting with the control section 3 which performs the image processing for an optical diagnosis etc. from the light which received, and this control section 3, and inputting the video signal by which the image processing was carried out The monitor 4 which displays an optical corresponding diagnostic image, and the recording device 5 which records a video signal, It connects with said optical transceiver section 2, the light for an optical diagnosis is transmitted, and it consists of light-scanning probe equipment (it is only hereafter written as a probe) 6 of the direct viewing type which carries out outgoing radiation of the light of an optical diagnosis to a tested part side from the tip side.
[0015] Moreover, a signal cable connects with a probe 6 and a control section 3 drives the actuator which constitutes the scan unit 19 (refer to drawing 4) which was built in end-of-the-probe section 6a, and which is mentioned later. And the focal location of the illumination light is scanned with a probe 6, the reflected light reflected from the focal location in a tested part by the scan is detected, and it images by the observation equipment side. In addition, observation equipment expresses the part except a probe 6 with drawing 1 (specifically the optical transceiver section 2, a control section 3, and a monitor 4.). In this case, even if it includes in observation equipment, it is not necessary to include a recording device 5.
[0016] The light source 7 in which the optical transceiver section 2 generates the light for an optical diagnosis as shown in drawing 2 , The photodetector 8 which detects the reflected light of the light illuminated to the specimen side by the probe 6, Consisting of a fiber 9 for optical transmissions, the two join together optically in the optical coupling section 10 near a center, and the fiber 9 for optical transmissions constitutes four terminals (coupler) 11a, 11b, 11c, and 11d which branched bidirectionally.
[0017] Usually, the laser oscillation machine which generates a laser beam as the light source 7 is adopted, terminal 11a of the fiber 9 for optical transmissions is connected to the light source 7, and incidence of the light generated in the light source 7 is carried out to terminal 11a. This light branches for Terminals 11b and 11d by the optical coupling section 10, and the light transmitted to terminal 11b progresses to the probe 6 side connected to that terminal 11b. The light supplied to this probe 6 side is drawn to that point 6a, and outgoing radiation is carried out from that apical surface.
[0018] Moreover, incidence of the reflected light from a tested part side is carried out to the apical surface of this probe 6, and that light progresses conversely and branches for Terminals 11a and 11c by the optical coupling section 10. Incidence of the light led to terminal 11c is carried out to the photodetector 8 by which opposite arrangement was carried out, and photo electric conversion is carried out to the terminal 11c. This signal by which photo electric conversion was carried out is inputted into the image-processing circuit 15 which constitutes the control section 3 shown in drawing 3 .
[0019] In addition, generally the fiber 9 for optical transmissions consists of branching ratios of 1:1, and with the gestalt of this operation, although the edge of 11d of terminals is closed, it is usable as a reserve when one of other three terminals 11a, 11b, and 11c becomes use impossible.
[0020] As shown in drawing 3 , a control section 3 consists of the light source drive circuit 12 which drives the light source 7, an X drive circuit 13 for scanning the light supplied to the probe 6 from the light source 7 in the direction of X, a Y drive circuit 14 for scanning in the direction of Y, and an image-processing circuit 15 that performs the image processing to the signal in which photo electric conversion was carried out by the photodetector 8.

[0021] X drive circuit 13 and Y drive circuit 14 are electrically connected with the scan unit 19 (actuators 28A and 28B) prepared in point 6a of a probe 6 by connecting the light source drive circuit 12 with the light source 7 electrically, and the input edge of the image-processing circuit 15 is electrically connected with the photodetector 8. Moreover, the outgoing end of the image-processing circuit 15 is connected with the monitor 4 and the recording device 5.
[0022] As shown in drawing 4 , the probe 6 of the gestalt of the 1st operation attaches the optical frame 18 made from tube-like hard at the tip of the tube 16 of the hollow which has flexibility through a holddown member 17. While arranging the scan unit 19 which performs light scanning inside this optical frame 18, the tip covering receptacle 21 furnished with the tip covering (cover glass) 20 as a light transmission nature member is attached in a part for opening at the tip of the optical frame 18, and point 6a is formed in it.
[0023] Connect with terminal 11b of said fiber 9 for optical transmissions, and the tip side of an optical fiber 22 has the centrum of a holddown member 17 let it pass, and the back end (end face) of the optical fiber 22 inserted in in said tube 16 is in the condition that the ferrule 23 was attached in the point in one, and is being fixed to the pore of the back end of the attachment component 25 of the shape of approximate circle tubing which constitutes the optical unit 24.
[0024] Moreover, while attaching the condenser lens 26 which condenses the light by which outgoing radiation is carried out and carrying out outgoing radiation of the illumination light to a specimen (body tissue 35 specifically shown in drawing 9) side so that it may be extended from apical surface 22a of an optical fiber 22, the optical unit 24 which receives the reflected light from a specimen side is constituted by the point of an attachment component 25.
[0025] In addition, apical surface 22a of an optical fiber 22 is ground by the flat surface of 8-degree slant. Moreover, as shown in drawing 4 , if the tip side of an optical fiber 22 should look at the sectional view of drawing 4 (B) from the horizontal direction, as it inclines in the vertical direction slightly, it is being fixed to the attachment component 25. Since drawing 4 (A) is a sectional view from the direction which intersects perpendicularly horizontally, by drawing 4 (A), it inclines to a space perpendicular direction and it is arranged. And the inclination of apical surface 22a of an optical fiber 22 is amended.
[0026] Therefore, it progresses in accordance with the optical axis 27 of a condenser lens 26, and is condensed with a condenser lens 26, and the illumination light by which outgoing radiation is carried out from apical surface 22a of an optical fiber 22 becomes spot-like with a focus 34. Moreover, the reflected light by the side of the specimen carries out incidence to apical surface 22a of an optical fiber 22 through a condenser lens 26, detects the incident light, and images the optical information over analyte. In this case, apical surface 22a of the location of a focus 34 and a small area of an optical fiber 22 becomes focal relation mutually about a condenser lens 26 (and refractive index in the tip covering 20 and the optical path between them), and the light by which is reflected by the specimen side and incidence is carried out to apical surface 22a of an optical fiber 22 forms confocal optical system so that it may be restricted to an about 34 focus thing. In addition, either a single mode fiber or a multimode fiber is OK as an optical fiber 22 and the fiber 9 for optical transmissions.
[0027] Actuator (it becomes low-speed driving side) 28A to which the back end is fixed to a holddown member 17, and the scan unit 19 drives the point of an attachment component 25 through the pars intermedia material 29, Actuator (it becomes high-speed driving side) 28B which drives the point of this attachment component 25 in the direction which intersects perpendicularly with the driving direction by said actuator 28A, The back end of this actuator 28B is held, and it consists of pars intermedia material 29 of the letter of the abbreviation for L characters by which that back end section is arranged between an attachment component 25 and a holddown member 17. In addition, while the tip of a tube 16 is fixed to the peripheral face of a holddown member 17, the back end 18 of the optical frame 18 is also being fixed.
[0028] As shown in drawing 5 , actuator 28A (the same is said of 28B) consists of a piezoelectric-device plate 30 which consists of a PZT component plate or a quartz plate equipped with the piezo-electric property etc., and a conductive member 31 longer than this piezoelectric-device plate 30. it is shown in drawing 4 -- as -- the back end of actuator 28A -- abbreviation -- horizontal plane 17a prepared in a part of periphery of the tubular holddown

member 17 -- moreover, the field of the conductive member 31 is being fixed to tip side-face (tip top side) 29a to which the tip extended to the tip side in the pars intermedia material 29 of the letter of the abbreviation for L characters, respectively.
[0029] Moreover, the back end of actuator 28B of another side is being fixed to back end section side-face 29b arranged at the back end side from the location where it became the direction which intersects perpendicularly with said side-face 29a in the pars intermedia material 29, and said actuator 28A was fixed to the condenser lens 26 in respect of the conductive member 31. The tip of this actuator 28B is being fixed to tip side-face 25a of an attachment component 25 in respect of the conductive member 31.
[0030] Moreover, the guide 32 is formed in horizontal plane 17a of said holddown member 17, side-face 29a of the pars intermedia material 29, side-face 29b, and side-face 25a of an attachment component 25, and Actuators 28A and 28B are led and fixed to said guide 32. Drawing 6 , drawing 7 , and drawing 8 show these guides 32. A view Fig. of the holddown member [in / in drawing 6 / drawing 4 (B)] 17, B view Fig. of the pars intermedia material [in / in drawing 7 / drawing 4 (B)] 29, and drawing 8 show C view Fig. of the attachment component 25 in drawing 4 (A).
[0031] As shown in drawing 4 , the tip of the signal cable 33 with which the actuators 28A and 28B of the scan unit 19 arranged in the optical frame 18 were made into the shape of a twisted pair is connected, and the back end of this signal cable 33 inserted in in the tube 16 is connected to X drive circuit 13 and Y drive circuit 14.
[0032] As shown in drawing 9 , the covering receptacle 21 for sealing that opening in watertight and protecting it is fixed to tip opening of the optical frame 18, and the tip covering (cover glass) 20 which penetrates light is being fixed to hole 21a prepared in the location which counters a condenser lens 26 in the central part in this covering receptacle 21. Therefore, outgoing radiation is carried out by the light source 7 from apical surface 22a of an optical fiber 22, and the light condensed with a condenser lens 26 penetrates the tip covering 20, and comes to be condensed in the shape of a spot with the focus 34 of the front. Moreover, a focus 34 will scan the inside of the scan layer 36 including the focus 34 two-dimensional by driving Actuators 28A and 28B.
[0033] It arranges so that the distance L37 (working distance: describe it as WD henceforth) of this focus 34 and front (front face) 20a which faces the body tissue 35 which is the specimen in the tip covering 20 may be set to 10 micrometer<=L <=2.0mm, and the effect of the reflected light by the tip covering 20 is mitigated, and it enables it to detect the reflected light from about 34 focus with the gestalt of this operation.
[0034] As for said optical unit 19, the watertight is maintained with a tube 16, the optical frame 18, the tip covering 20, and the covering receptacle 21. Moreover, a condenser lens 26 and hole 21a of the tip covering 20 and the covering receptacle 21 have the area of extent which does not interrupt the light by which outgoing radiation is carried out from said optical fiber 22. In addition, although drawing 4 etc. showed the scan unit 19 and the optical unit 24, otherwise, the configuration of explaining to the following drawing 10 (A) etc. is sufficient as them.
[0035] As shown in drawing 10 (A), the scan unit 19 is formed in [an optical unit] one, and this scan unit 19 consists of a condenser lens 26, the lens frame 40, the spacing tubing 41, a scanning mirror 42, the mirror base 43, the optical fiber standing ways 44, an optical fiber 22, a flexible substrate 45, and a substrate 46. The back end of the optical frame 18 is fixed at the tip of a tube 16 through a holddown member 17 like the case of drawing 4 , and as the back end of the covering receptacle 21 furnished with the tip covering 20 fits in at the tip of the optical frame 18, it is being fixed to it.
[0036] Moreover, in the case of drawing 10 (A), the tip of a fiber 22 is in the condition that the ferrule 23 was fixed in one, and is being fixed in contact with the optical axis 27 of the condenser lens 26 in the optical fiber standing ways 44 fixed inside the optical frame 18, and leaning slant surface part 44a. In this case, ferrule 23 part by the side of the tip periphery of an optical fiber 22 is cut in the shape of a taper (the shape of a cone), is lacked, and the ferrule 23 has become a wrap configuration thinly in fiber apical surface 22b.
[0037] The back end of a scanning mirror 42 is being fixed to the front end of the optical fiber standing ways 44 so that fiber apical surface 22b may be approached and countered through the

mirror base 43. Moreover, the spacing tubing 41 which has the configuration of the character of abbreviation KO is arranged to the anterior part of this scanning mirror 42, and where a predetermined distance is secured, the condenser lens 26 is being fixed to it with the lens frame 40. Drawing 10 (B) shows the D-D cross section of drawing 10 (A).
[0038] In addition, the back end of the lens frame 40 is positioned in contact with the spacing tubing 41, and the lens frame 40 is being fixed, when have the crevice which is that the diameter of is expanded in the shape of a level difference, and contain a condenser lens 26 from a before side to this crevice, and a before side inserts the auxiliary ring 47 in that front end side, contains in the covering receptacle 21, carries out fitting of this covering receptacle 21 to the optical frame 18 and pushes against a back end side.
[0039] Moreover, the vacuum evaporationo film 48 of light reflex nature is given to the part of optical-axis 27 near [the rear-face side in a condenser lens 26] except for the hole 49 of the core. That is, the vacuum evaporationo film 48 of the light reflex nature of the magnitude corresponding to the diameter of the flux of light in the condenser lens 26 of the illumination light by which direct outgoing radiation was carried out is given near the core of the rear face which counters the optical fiber 22 in a condenser lens 26 as shown in drawing 11 except for the main hole 49 from the optical fiber 22.
[0040] The mirror base 43 where the scanning mirror 42 was fixed is being fixed to said spacing tubing 41, and the tip side of the optical fiber 22 fixed to the optical fiber standing ways 44 through the ferrule 23 is inserted in the centrum of this mirror base 43.
[0041] Moreover, a substrate 46 and the flexible substrate 45 are arranged inside the optical frame 18, and the back end of the flexible substrate 45 is connected with the electrical cable 50 with soldering so that a scanning mirror 42, the mirror base 43, and the optical fiber standing ways 44 may be straddled.
[0042] To said medial axis, an optical fiber 22 leans and is arranged so that the optical axis 27 of light and the medial axis of a condenser lens 26 by which the tip of the ferrule 23 of the shape of an optical fiber 22 and a taper ground in one did not contact a scanning mirror 42, but separated slight spacing, and countered, and direct outgoing radiation was carried out from the optical fiber 22 may be in agreement.
[0043] In addition, it is arranged so that the optical axis 27 of the hole 49 to which the vacuum evaporationo film 48 of the light reflex nature of a condenser lens 26 is not given, the hole 51 (refer to drawing 12) prepared in the scanning mirror 42, and the illumination light by which direct outgoing radiation is carried out from apical surface 22a of an optical fiber 22 may be in agreement.
[0044] A scanning mirror 42 etches to one field (it considers as a front face) of a silicon substrate 52, as shown in drawing 12 , and it forms a hollow 53. Moreover, it etches also from the rear-face side of a silicon substrate 52, and the hollow section 54 and a through hole 55 are formed.
[0045] Moreover, the front-face side of a silicon substrate 52 is pasted, and the plate 56 insulated electrically [a silicon substrate 52] by the oxide layer on a silicon substrate 52 is formed. Furthermore, after carrying out a mask appropriately, a nitride 57 is formed in the top face of a plate 56, this plate 56 part is etched by leaving a part (that is, mirror section 58) required for reflection, and the mirror section 58 is formed.
[0046] Drawing which looked at the mirror section 58 at this time from the top face is shown in drawing 13 . The half-tone-dot-meshing sections 59a, 59b, 59c, and 59d in drawing 13 will show the part which did not form a nitride 57, and will be removed by etching. As furthermore shown in drawing 14 , a conductive layer is formed from on drawing 13 , and Electrodes 60a, 60b, 60c, and 60d and the circuit patterns 61a, 61b, 61c, and 61d which drive a scanning mirror 42 (mirror section 58) electrically are manufactured.
[0047] One pair of electrodes 60a and 60b and Electrodes 60c and 60d serve also as the role of a mirror. Here, the part which is not covered with a nitride is removed by etching appropriately.
[0048] Thus, 1 pair of electrode 60a formed near the hole 51 so that it might counter in the vertical direction, Hinge region 62a of the longitudinal direction by which 60b was prepared in the edge in the half-tone-dot-meshing sections 59a and 59b, inclining in the vertical direction by 62b

-- being possible (tilting being possible) -- 1 pair of electrode 60c formed so that it might be held and the outside might be countered at a longitudinal direction -- Inclining to a longitudinal direction by the hinge regions 62c and 62d of the lengthwise direction established in the edge in the half-tone-dot-meshing sections 59c and 59d is held possible, and it forms 60d of gimbal type mirror sections 58.
[0049] In addition, electrodes 60a, 60b, 60c, and 60 are connected to circuit patterns 61a, 61b, 61c, and 61d, respectively, these circuit patterns 61a, 61b, 61c, and 61d are connected at the tip of an electrical cable 50 through a substrate 46 and the flexible substrate 45, and the back end of this electrical cable 50 is connected to X drive circuit 13 and Y drive circuit 14.
[0050] And it drives so that Electrodes 60a and 60b and electrodes 60c and 60 may tilt, respectively, and it can be made to carry out by outputting a driving signal from X drive circuit 13 and Y drive circuit 14 the field scan of the focus 34. In addition, the hole 51 of the magnitude of extent which does not interrupt the illumination light to which outgoing radiation of the core of the mirror section 58 was carried out from the optical fiber 22 is formed.
[0051] Next, the basis which set said working distance WD as 10 micrometer<=L <=2.0mm is explained with reference to drawing 15 , drawing 16 , drawing 17 and Table 1, Table 2, Table 3, and Table 4. Drawing 15 shows the optical path in the optical system 0.5 and whose WD the wavelength of 680nm and numerical aperture NA are 1.0mm, and Table 2 is data in which the configuration of the condenser lens 26 in said optical system is shown by Table 1 showing change of the optical-character ability when changing the refractive index (refractive index from the tip covering 20 to a condensing point) of a photographic subject in the optical system shown in this drawing 15 .
[0052]
Table 1 (optical-character ability change accompanying refractive-index change of a photographic subject by the case where WD is 1.0mm) -------------------------- Refractive index of a photographic subject | 1.33 | 1.4 | 1.5 Wave aberration RMS | 0.033 | 0.001 | 0.036 -------------------------- Table 2 (the lens data corresponding to Table 1 and the wavelength to nd are 587.56nm)
-------------------------------------- RDY (radius of curvature) THI (between fields) nd (refractive index) Vd (Abbe number)
-------------------------------------- The 1st page INFINITY 11.20000 The 2nd page 2.36494 1.405319 1.81474 The 37.03 3rd side -3.91541 1.013891 The 4th page INFINITY 0.300000 1.51630 The 64.10 5th side INFINITY 1.005000 1.41000 37.03 -- the 6th page INFINITY 0.000000 -- 2nd page K:0.000000 A:-.977942E-02 E-02 -- 3rd page K:0.000000 A:0.272728E-01 B:-.45647E-03 --------------------------
Moreover, change of optical-character ability when the optical path in the optical system 0.5 and whose WD the wavelength of 680nm and numerical aperture NA of drawing 16 are 2.0mm changes the refractive index of a photographic subject in the optical system of drawing 16 in Table 3 is expressed, and Table 4 shows the data of the configuration of the condenser lens 26 in said optical system. Moreover, drawing 17 expresses the distance from a focus 34, and the light-receiving reinforcement of the light from the location with a ratio.
[0053]
Table 3 (optical-character ability change accompanying refractive-index change of a photographic subject by the case where WD is 2.0mm) -------------------------- Refractive index of a photographic subject | 1.33 | 1.4 | 1.5 Wave aberration RMS | 0.071 | 0.001 | 0.077 -------------------------- Table 4 (the lens data corresponding to Table 3 and the wavelength to nd are 587.56nm)
-------------------------------------- RDY (radius of curvature) THI (between fields) nd (refractive index) Vd (Abbe number)
-------------------------------------- The 1st page INFINITY 11.20000 The 2nd page 2.41353 1.377416 1.81474 The 37.03 3rd side -3.80224 0.324356 The 4th page INFINITY 0.300000 1.51630 The 64.10 5th side INFINITY 2.005000 1.41000 37.03 -- the 6th page INFINITY 0.000000 -- 2nd page

K:0.000000 A:-.864143E-02 E-03 --- 3rd page K:0.000000 A:0.258114E-01 B:-.701481E-03 ------------------------------ K, A, and B It is an aspheric surface multiplier at the time of setting a lens side configuration as the eventh aspheric surface symmetrical with rotation. [in / in addition / Table 2 and Table 4] Here, when the direction of an optical axis is made into a Z direction, a field configuration (each point (Z component in X and Y)) is expressed as follows.
[0054] Z=1-/RDYx(S^2) (1+SQRT (1-(K+1) x1/RDY^(-2) xS^2)) +Ax (it is S^4+BxS^6, however S^2=X^2+Y^2.) Moreover, S^N S N ** is shown (it is here and N shows 2, 4, 6, or -2 grade). Moreover, SQRT (C) C A square root is expressed.
[0055] The 1st page is an apical surface (confocal pinhole) of an optical fiber 22 further again. the 2- the 3rd page -- a condenser lens 26 (a lens effective diameter is phi2.4mm)
the 4- the 5th page -- cover glass (tip covering 20)
Page [5th] - the 6th page is a photographic subject (it is a refractive index 1.4 to the wavelength of 680nm). In addition, the optical design is made on the assumption that the refractive index of the photographic subject in drawing 15 and drawing 16 is set to 1.4, when incidence of the light with a wavelength of 680nm is carried out.
[0056] In confocal optical system, it is effective in removing the reflected light from the photographic subject which separated from the focal location. This is called Z resolution (resolution of the depth direction). According to the depth location of a photographic subject, the light-receiving quantity of light changed and the full width at half maximum is defined as Z resolution (refer to drawing 17).
[0057] This Z resolution is expressed as 1.28lambdan/(NA-NA), when lambda and a photographic subject refractive index are set to n and it sets optical-system numerical aperture to NA for the wavelength of the light of the light source 7. Moreover, the magnitude of a nucleus has Z desirable resolution of 5 micrometers or more, in order to observe a nucleus, since it is several micrometers - about about ten micrometers. for example, 5 micrometers Z -- in the optical system of resolution, if the location of a photographic subject is located from a focal location in the location of 10 micrometers when change of light-receiving reinforcement follows normal distribution like drawing 17 , the light-receiving quantity of light will fall or less to about 1/1000.
[0058] The glass which generally coated the antireflection film as the quality of the material of the tip covering 20 is used. The reflection factor It is setting WD as 10 micrometers or more to being about 1/100, since the rates of internal reflection of a living body cell (a cell membrane, nucleus) are about 1 / 1000 to 1/100000. As compared with the amount of reflected lights from the tip covering 20, the reflected light from the living body cell of sufficient amount for observation can be obtained.
[0059] That is, the light income (referred to as S) by the reflection from the living body cell in a focus 34 becomes about 1 / 1000 to 1/100000, and it can set it as S>N that light income (referred to as N) can be set as reflection from the tip covering 20 below at x (1/100) (1/1000) extent by setting the location of the front face of the tip covering 20 as 10 micrometers or more from a focus 34, and to put in another way.
[0060] Moreover, when observing various living body cells, body tissues, etc., a refractive index changes with those classes. When observing by furthermore inserting into a coelome, body fluid enters between the tip covering 20 and a body tissue 35.
[0061] Body fluid has a refractive index which a body tissue 35 is large and is different. the photographic subject which has about 1.33 to 1.5 refractive index when the refractive index of 1.33 and a body tissue 35 observes the body tissue 35 in a coelome, since the refractive index of water is before and after 1.4 -- it is -- good optical system -- it is necessary to realize resolution
[0062] although there is wave aberration RMS, if the value becomes larger than 0.07 as an index showing optical-character ability -- optical system -- degradation of resolution starts. if WD is 2.0mm or less when the refractive indexes of a photographic subject are 1.33-1.5, although the value of wave aberration RMS became large and optical-character ability has deteriorated so that refractive-index change of the specimen and WD are larger than Table 1 and 3 -- wave aberration RMS -- it can stop -- optical system -- it turns out that resolution is maintainable.

[0063] if WD is 2.0mm or less even if it is the light source which has wavelength other than 680nm, although 680nm was taken up as light source wavelength with the gestalt of this operation -- wave aberration RMS -- it can stop -- optical system -- resolution is maintainable. The light is sufficient as wavelength other than said 680nm, and infrared light, ultraviolet radiation, near-infrared light, etc. are sufficient as it.
[0064] Z resolution is set to 4.9 micrometers on the wavelength of 680nm of the illumination light like the gestalt of this operation at the time of NA0.5. This has sufficient resolution for observation of a body tissue (a cell membrane, nucleus).
[0065] Next, an operation of the gestalt of this operation is explained. In the above configuration, it inserts into a coelome through the treatment implement insertion channel of the endoscope which does not illustrate a probe 6, and pushes against an observation part. In this condition, the light source 7 is driven by the light source drive circuit 12, and the light source 7 generates light. Incidence of this light is carried out to terminal 11a which consists of fibers 9 for optical transmissions, and that light branches for terminal 11b and 11d of terminals by the optical coupling section 10. Although what branched for 11d of terminals is led to a closing edge, incidence of the light which branched to terminal 11b is carried out to the optical fiber 22 built in the probe 6, and it is led to point 6a of a probe 6.
[0066] By the optical unit 24, after carrying out outgoing radiation of the light led to point 6a of a probe 6 from apical surface 22a of an optical fiber 22, it is condensed with a condenser lens 26 and it penetrates the tip covering 20, and as shown in drawing 9 , it connects a focus 34 near the front face of a body tissue 35. At this time, it is scanned within the scan layer 36 to which the actuators 28A and 28B of the scan unit 19 drive, and an optical axis 27 and a focus 34 cross at right angles with the driving signal from X drive circuit 13 and Y drive circuit 14 of a control section 3.
[0067] And the reflected light from the focus 34 of a body tissue 35 and the reflected light from front 20a of the tip covering 20 pass along the terminals 11b and 11c of an optical fiber 22 and the fiber 9 for optical transmissions, and incidence is carried out to the FATO detector 8.
[0068] The reflected light by which incidence was carried out is changed into an electrical signal by the photodetector 8, and is transmitted to the image-processing circuit 15. At this time, the value of an electrical signal supports the amount of reflected lights from the scan layer 36 of the focus 34 of a body tissue 35.
[0069] The image-processing circuit 15 images the electrical signal transmitted from the photodetector 8 as brightness information in a corresponding focal location with reference to the drive wave of X drive circuit 13 and Y drive circuit 14, and displays it on a monitor 4. Moreover, if needed, it transmits to a recording apparatus 5 and records as electronic data.
[0070] At this time, point 6a of a probe 6 which has the scan unit 19 shown in drawing 4 is scanned in the following ways. Said X drive circuit 13 impresses an electrical potential difference forward by the sine wave to actuator 28B. Moreover, the frequency of this sine wave is set as the resonance frequency of the system which consists of the optical unit 24 and the scan unit 19.
[0071] The piezoelectric-device plate 30 of actuator 28B repeats telescopic motion according to the electrical-potential-difference value which changes in the shape of a sine wave. On the other hand, since it does not expand and contract, the conductive member 31 of actuator 28B transforms actuator 28B in the direction 64 (drawing 18 the vertical direction) in drawing 18 . It drives so that a condenser lens 26 may also vibrate, therefore the direction of a focus is scanned in the one direction (the vertical direction) because the attachment component 25 (tip side to the fixed back end) to which actuator 28B was fixed vibrates in connection with this motion.
[0072] An electrical potential difference forward by the saw-tooth wave is impressed to actuator 28A of another side by said Y drive circuit 14. By impressing the electrical-potential-difference value of this saw-tooth wave, actuator 28A more specifically deforms in a different direction from said actuator 28B, and said direction and the direction 65 (horizontal in drawing 18) which intersects perpendicularly. A focal location is scanned in the direction 65 which intersects perpendicularly in the direction 64 accompanying a motion of said actuator 28B because the

attachment component 25 connected to actuator 28A vibrates through the pars intermedia material 29 and actuator 28B in connection with this motion.
[0073] At this time, the frequency of a saw-tooth wave consists of a value which did the division of the frequency of said sine wave by the number of the scanning lines, and thereby, the field scan of the focus 34 is carried out, taking the synchronization in the scan of two directions.
[0074] Moreover, the scan of the focus 34 in end-of-the-probe section 6a shown in drawing 10 (A) is explained with reference to drawing 19 . The illumination light by which outgoing radiation was carried out from tip 22b of an optical fiber 22 passes along the through hole 55 of a silicon substrate 52, and the hole 51 of the core of the mirror section 58, and faces to a condenser lens 26. It is reflected by the vacuum evaporationo film 48 of the light reflex nature of a condenser lens 26, and this light is reflected in this mirror section 58 toward the mirror section 58 of a scanning mirror 42 with breadth.
[0075] Then, this light progresses in the direction of the opposite side (front face) of this condenser lens 26 from the part to which the vacuum evaporationo film 48 of the light reflex nature of a condenser lens 26 is not given, it is condensed in the meantime, and it progresses through the tip covering 20, and becomes spot-like with a focus.
[0076] In this case, the serrate electrical potential difference which a phase is mutually reversed to the electrodes 60c and 60d which constitute the mirror section 58, and has the same amplitude in them is impressed, by forming capacitance in the GND section formed in the hollow section 54, electrostatic force occurs and the mirror section 58 vibrates considering hinge regions 62c and 62d as a shaft.
[0077] Moreover, the electrical potential difference of the sine wave which a phase is mutually reversed also to the electrodes 60a and 60b of another side, and has the same amplitude in them is impressed, by forming capacitance in the GND section formed in the hollow section 54, electrostatic force occurs and the mirror section 58 vibrates considering hinge regions 62a and 62b as a shaft.
[0078] At this time, the frequency of a sine wave is the resonance frequency of the system which consists of the mirror section 58, and the frequency of said saw-tooth wave is equal to the value which did the division of the frequency of a sine wave with the scanning line. The inclination of the mirror section 58 changes every moment, and the field scan of the location of the focus 34 of the illumination light is carried out in connection with it by both the electrical-potential-differences value.
[0079] The gestalt of this operation has the following effectiveness. It becomes observable [a body tissue 35] by making smaller than the light from a body tissue 35 light by which is reflected other than body tissue 35 and incidence is carried out to a photodetector 8 by setting the working distance WD as 10 micrometer<L <2.0mm, maintaining optical-character ability required observing a body tissue 35.
[0080] Moreover, since an optical axis 27 is fixed to a condenser lens 26 when a focus is scanned with the configuration shown in drawing 4 , the design of a condenser lens 26 is easy. On the other hand, if a focus is scanned with the configuration shown in drawing 10 , the member of mass which operates is light only because of the mirror section 58, and a scan at a high speed can be realized.
[0081] (Gestalt of the 2nd operation) The gestalt of operation of the 2nd of this invention is explained below with reference to drawing 20 . In addition, except covering receptacle 21, since it is the same configuration as the gestalt of the 1st operation, only a different part from the gestalt of the 1st operation is explained.
[0082] abbreviation whose covering receptacle 21 has a hole as shown in drawing 20 -- tubular -- it changed more and has projected in the direction of a body tissue 35 from front 20a which faces the body tissue 35 of the tip covering 20. Moreover, beveling 21b and 21c is performed to the ridgeline of apical surface 21a which touches the body tissue 35 in said covering receptacle 21.
[0083] In addition, as shown in drawing 21 , it may be made to make the tip side of the covering receptacle 21 instead of beveling 21c for example, by the side of the periphery in drawing 20 into the shape of an abbreviation semi-sphere. The die length s71 of 21d of holes from apical surface

21a in said covering receptacle 21 to front 20a of the tip covering 20 It is located in the same as that of apical surface 21a to which a focus 34 touches the body tissue 35 of said covering receptacle 21, or 21d of said holes. And when point 6a of a probe 6 is pressed against a body tissue 35 and said organization 35 has entered into 21d of holes at the time of observation, It is set up so that the distance d72 of front 20a of the tip covering 20 and the front face of a body tissue 35 may be set to 10 micrometer<=d <=2.0mm corresponding to the working distance WD (L37).

[0084] In addition, as the tip covering 20 fits into hole 21e which made diameter expansion the back end side of 21d of holes of said covering receptacle 21, it is attached in it.

[0085] Since an organization 35 enters and an amount changes with cross sections of 21d of said holes etc., said die length s71 is not unique, but when 73 are aboutphi1-1.5mm of diameters D of the cross section whose WD(s) are 40 micrometers and 21d of said holes, it is set to 0.1-0.6mm, for example.

[0086] In addition, the configuration shown in drawing 22 and drawing 23 is sufficient as the configuration of said covering receptacle 21. Drawing 22 is the external view of point 6a of a probe 6, and drawing 23 is drawing of longitudinal section of point 6a of a probe 6.

[0087] It projects identically to front 20a which faces the body tissue 35 in the covering receptacle 21, or slightly, and is fixed to the covering receptacle 21, and the tip covering 20 is formed in this front 21a so that two or more lobes 74 may project in the direction of a body tissue 35. A ridgeline fails to be deleted, for example, point 74a of said lobe 74 has the configuration of an abbreviation semi-sphere.

[0088] As shown in drawing 23 , said lobe 74 moreover, the distance B75 which projects from front 20a in said tip covering 20 To the die length L37 of the working distance WD, fill the relation of B>=L and point 6a of a probe 6 is pressed against a body tissue 35. When said organization 35 has entered the crevice 76 constituted by said lobe 74, it is set up so that the distance d72 of front 20a of the tip covering 20 and the front face of a body tissue 35 may be set to 10 micrometer<=d <=2.0mm corresponding to the working distance WD.

[0089] Next, an operation of the gestalt of this operation is explained. The die length s71 of the part into which the covering receptacle 21 projects, or B75 fills the relation between the die length L37 of the working distance WD, s>=L, or B>=L. And when point 6a of a probe 6 is pressed against a body tissue 35 and said organization 35 has entered into 21d of holes at the time of observation, A focus 34 can be located near [surface] a body tissue 35 by setting it as the die length from which the distance d72 of front 20a of the tip covering 20 and the front face of a body tissue 35 is set to 10 micrometer<=d <=2.0mm corresponding to L37.

[0090] The gestalt of this operation has the following effectiveness. Since a focus 34 is easily fixable near [surface] a body tissue 35 with easy structure, from a body tissue 35, many reflected lights can be obtained and a body tissue 35 can be observed certainly.

[0091] By setting L37 as 10 micrometer<=d <=2.0mm like the gestalt of the 1st operation in addition to it, a S/N ratio can improve and a body tissue 35 can be observed more certainly.

[0092] Cleaning of front 20a of the tip covering 20 becomes easy by furthermore making it the configuration of drawing 22 and drawing 23 . In addition, the same effectiveness is acquired even if it forms the slit group 80 in the covering receptacle 21 instead of a lobe 74 about this effectiveness at a radial, as shown in drawing 24 .

[0093] Outgoing radiation is carried out through two or more light transmission nature members including the condensing optical system which condenses the illumination light which [additional remark] 0. light equipment emits from the tip of an optical transmission member. In the light-scanning probe equipment which transmits the reflected light of said illumination light from said tested part which serves as said tip and confocal relation to said two or more light transmission nature members, scans the focus formed in a tested part side, and is obtained by this scan to observation equipment Among said two or more light transmission nature members arranged on the optical path of said illumination light, the distance of a tested part, the nearest light transmission nature member, and the focus of said illumination light Light-scanning probe equipment characterized by having arranged so that the amount S of reflected lights which reflects by the total amount N and tested part of the reflected light which reflect by the end

face of said light transmission nature member, and are transmitted to observation equipment, and is transmitted to observation equipment may serve as S>N.

[0094] 1. In light-scanning probe equipment according to claim 1, it is characterized by having arranged said focus from said light transmission nature member to the tested part side so that the distance L with the light transmission nature member nearest to the focus of said illumination light and said focus established on the optical path of the illumination light may serve as 10 micrometer<=L.

2. In light-scanning probe equipment according to claim 1, it is characterized by having arranged said focus from said light transmission nature member to the specimen side so that the distance L with the light transmission nature member nearest to the focus of said illumination light and said focus established on the optical path of the illumination light may be set to L<=2.0mm.

[0095] 3. In light-scanning probe equipment according to claim 1, it is characterized by having arranged said focus from said light transmission nature member to the tested part side so that the distance L with the light transmission nature member nearest to the focus of said illumination light and said focus established on the optical path of the illumination light may be set to 10 micrometer<=L <=2.0mm.

4. In light-scanning probe equipment according to claim 2, it is characterized by setting up the die length of a lobe so that the distance d of the field and specimen front face which face the tested part of said light transmission nature member may serve as 10 micrometer<=d.

[0096] 5. In light-scanning probe equipment according to claim 2, it is characterized by setting up the die length of a lobe so that the distance d of the field and specimen front face which face the tested part of said light transmission nature member may be set to d<=2.0mm.

6. In light-scanning probe equipment according to claim 2, it is characterized by setting up the die length of a lobe so that the distance d of the field and specimen front face which face the tested part of said light transmission nature member may be set to 10 micrometer<=d <=2.0mm.

[0097] 7. While Transmitting Illumination Light Which Light Equipment Emits in Claims 1, 2, and 3 and Carrying Out Outgoing Radiation from End Side to Tested Part The means of communication which carries out incidence of the reflected light of said illumination light from said tested part, and transmits it to observation equipment from said end side, The condensing optical system which condenses said illumination light by which outgoing radiation is carried out from said end side of said means of communication, A fixed means to fix said condensing optical system with said end side of said means of communication, Light-scanning probe equipment characterized by providing the first migration means which makes the optical axis of said illumination light move said fixed means in the direction which carries out an abbreviation rectangular cross, and the second migration means which makes it move in the direction which carries out an abbreviation rectangular cross at the optical axis of said illumination light, and is different from said first migration means.

[0098] 8. While Transmitting Illumination Light Which Light Equipment Emits in Claims 1, 2, and 3 and Carrying Out Outgoing Radiation from End Side to Tested Part The means of communication which carries out incidence of the reflected light of said illumination light from said tested part, and transmits it to observation equipment from said end side, The movable plate in which opening and the 1st reflector for said illumination light to pass were established, Light-scanning probe equipment characterized by having the base material which supports said movable plate, the 2nd reflector which turns to said 1st reflector the illumination light which passed said opening, and is reflected, and the condensing optical system which condenses the observation illumination light reflected from said 1st reflector.

[0099] 9. It is light-scanning PUROPU equipment characterized by forming said 2nd reflector in said condensing optical system and one in additional remark 8.

10. The means of communication of additional remark 7 and eight publications is characterized by consisting of an optical fiber.

11. It is characterized by the optical fiber of additional remark 10 publication consisting of a single mode fiber.

12. It is characterized by the optical fiber of additional remark 10 publication consisting of a multimode fiber.

[0100]
[Effect of the Invention] The amount of incident light by which is reflected from the body tissue near [focal] the illumination light, and incidence is carried out to observation equipment is larger than the amount N of incident light by which according to the configuration according to claim 1 is reflected by the light transmission nature member prepared on the optical path, and incidence is carried out to observation equipment, and it becomes possible to observe a body tissue.
[0101] Since many amounts of incident light by which can position the focus of the illumination light easily near the front face of a photographic subject, and are reflected from the body tissue near [focal] the illumination light, and incidence is carried out to observation equipment are obtained according to the configuration according to claim 2, a body tissue image can be obtained stably. Moreover, the effectiveness that it is stably fixable with easy structure is acquired. According to the configuration according to claim 3, the same part is stably observable by the high S/N ratio.

[Translation done.]